NON-ANATECTIC MIGMATITES IN GILPIN COUNTY, COLORADO

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ABSTRACT

To test the anatectic theory of migmatite formation, modal analyses and field studies were made of migmatites in Gilpin County, Colorado. It was demonstrated that these migmatites were not formed by anatexis, but by injection of SiO_2-rich hydrous fluids derived from nearby granite pegmatite dikes.

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It has been suggested by various petrologists (Turner and Verhoogen, 1960; Walton, 1960; Barth, 1963) that many migmatites are formed by anatexis of metamorphic rocks, and that migmatization thus represents an early stage in the generation of granitic magmas. This theory was tested during the course of mapping the geology of the Pine Creek area, Gilpin County, Colorado (Lowman, 1963; Figure 1). This area is largely underlain by Precambrian metasediments (formerly designated Idaho Springs formation), chiefly biotite-quartz-plagioclase and microcline-quartz-plagioclase gneisses of the almandine-amphibolite facies. The biotite gneisses are extensively migmatized, the degree of migmatization generally corresponding to the degree of deformation of the gneisses.

The metasomes (granular, igneous-looking portions) of anatectic subsolvus migmatites should have modal compositions close to the thermal valley of the hydrous quartz-orthoclase-plagioclase system, as shown by the experimental studies of Tuttle and Bowen (1958) and Winkler and his collaborators (1957, 1958, 1960, 1961a, 1961b). However, it was discovered (Lowman, 1963, p. 60-72) that a significantly large proportion of migmatite metasomes in the Pine Creek area have modal compositions well outside the thermal valley (Table 1 and Figures 2 and 3). It is also apparent that these metasomes would not, in several specimens, fit the norm-based definition of "granite" proposed by Tuttle and Bowen (triangle a-b-c in Figures 2 and 3) nor the mode-based definition proposed by Chayes (1957), although "metasome" is generally defined as the "granitic" component of migmatites (Turner and Verhoogen, 1960, p. 370).

Further field investigations during 1963 stimulated by this unexpected discovery showed that the quartz-rich metasomes, as well as many if not all of the more granitic ones, are traceable to granite pegmatite dikes (Figures 4-10). The dikes and the migmatites are in general characterized by sharp contacts, an absence of mafic border zones, and deflection of wall-rock foliation, suggesting formation by injection of fluids, rather than by metasomatism. This suggestion is strengthened by the observed association of intense deformation and migmatization.

It has thus been demonstrated that although migmatites are usually defined as having a "granitic" component, this component is not necessarily granite in the modern sense. This discovery, and the described field relations, imply that these particular migmatites were not formed by anatexis.

It appears that modal analyses of migmatite metasomes provide a useful method for distinguishing arterites (migmatites formed by injection) from venites (migmatites formed by anatexis).

The migmatite occurrences described here are also of interest as clear examples of pegmatite-derived quartz bodies which may represent the last part of the magmatic stage in pegmatite formation (Jahns, 1955, p. 1105).

Acknowledgments

I am grateful to Drs. L. S. Walter and B. M. French for their criticism of the manuscript.

Table I

<u>Modes of Migmatites (Volume %)</u>

Minerals	178	215	223	531	536B	710A	111
Quartz	24.9	34.3	30.9	37.2	43.2	77.7	64.3
Microcline	45.8	43.3	35.2	9.6	--	11.5	0.5
Plagioclase	25.0	17.2	29.7	44.5	50.0	9.3	25.4
Biotite	2.6	5.0	4.2	8.7	3.1	1.5	8.1
Muscovite	1.4		tr		3.4		tr
Chlorite							0.4
Magnetite	0.3	0.4		0.1	0.4		C.8
Zircon	tr		tr				tr
Total	100.0	100.0	100.0	100.1	100.1	100.0	99.8
Number of etched slabs or sections*	3	3	3	2	1 (section)	2	2 (sections)
Total measurement area (mm^2)	2100	900	2000	1170	600	2100	950
Total number of points	4500	2600	3800	1900	2000	3300	3200
IC Number	26	38	24	40	25	23	40
Plagioclase composition	An_{25}	An_{25}	An_{37}	An_{35}	An_{46}	An_{23}	An_{25}

* Counts were made on slabs etched and stained by Broch's (1961) method or on stained sections; the method is described elsewhere (Lowman, 1963).

Field Occurrences -

#178 - Outcrop sample from southeast slope of Blackhawk Peak. Analysis of metasome only.

#215 - Outcrop sample from south slope of Blackhawk Peak. Analysis of metasome only. Typical migmatite or granite gneiss, strongly contorted.

#223 - Outcrop sample from south slope of Blackhawk Peak. Analysis of metasome only. In field notes as granite gneiss and pegmatite, strongly folded.

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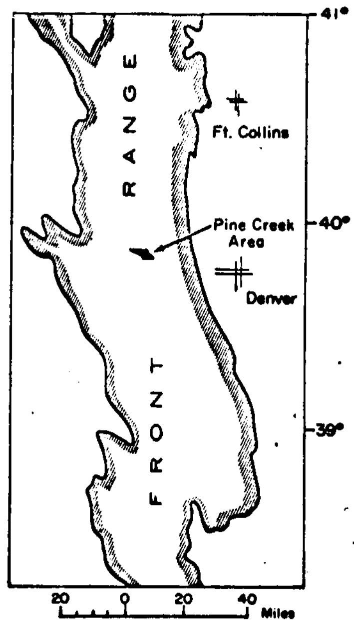
Illustration Captions

Figure 1	Index map
Figure 2	Modal proportions of migmatite metasomes. Analyses marked by open circles taken from Harrison and Wells (1956). Triangle a-b-c indicates limits of norm-based "granite" composition suggested by Tuttle and Bowen (1958).
Figure 3	Modal proportions of migmatite metasomes compared with compositions of experimentally produced liquids. Quartz-feldspar line from Tuttle and Bowen (1958).
Figure 4	Outcrop of typical migmatite in biotite-quartz-plagioclase gneiss, on old U.S. 40 at west end of Idaho Springs. Portions of the metasomes illustrated are exceptionally high in quartz.
Figure 5	Outcrop of typical migmatite in biotite-quartz-plagioclase gneiss on North Clear Creek about 1 mile west of the point where Colorado Rt. 119 leaves the creek, on road to Apex. Most metasomes illustrated are exceptionally high in quartz.
Figure 6	Exposure of biotite-quartz-plagioclase gneiss and amphibolite cut by a pegmatite dike and migmatites derived from the dike, on north side of Interstate 70 about 1/2 mile west of its intersection with Colorado Rt. 119.
Figure 7	Exposure of biotite-quartz-plagioclase gneiss and amphibolite cut by a pegmatite dike and migmatites derived from the dike, approximately same location as Figure 6.
Figure 8	Exposure of amphibolite and biotite-quartz-plagioclase cut by pegmatite dike and migmatites derived from it (above hammer), approximately same location as Figure 6.
Figure 9	Close view of exposure illustrated in Figure 8, showing deflection of foliation in country rock and relation between metasome and dike.
Figure 10	Exposure of biotite-quartz-plagioclase gneiss and amphibolite cut by pegmatite dike and migmatites derived from it, approximately same location as Figure 6. Note especially the white stringers (directly below hammer) derived from the pegmatite; these are almost entirely quartz.

Fig. 1



41°
RANGE
Ft. Collins
Pine Creek Area
40°
Denver
FRONT
39°
20 0 20 40 Miles

Figure 2

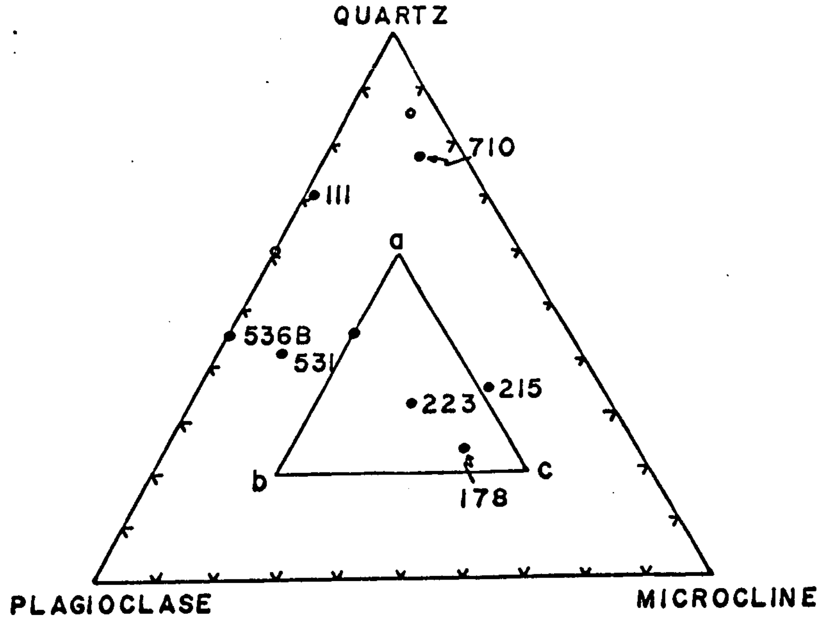

QUARTZ
710
111
a
536B
531
223
215
b
c
178
PLAGIOCLASE
MICROCLINE

Figure 3

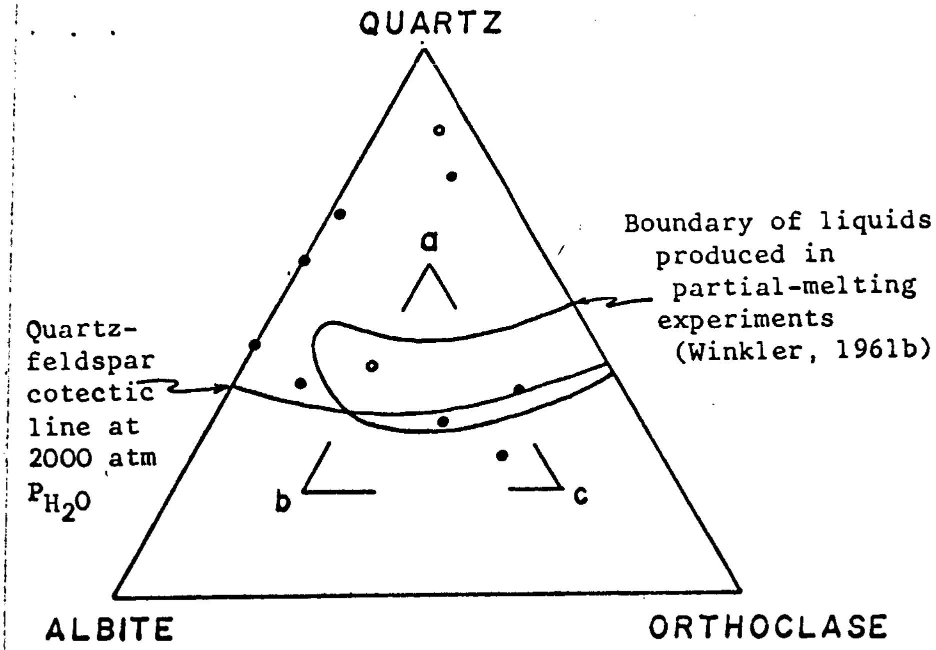

QUARTZ
a
Boundary of liquids produced in partial-melting experiments (Winkler, 1961b)
Quartz-feldspar cotectic line at 2000 atm P_{H_2O}
b
c
ALBITE
ORTHOCLASE

Fig. 4

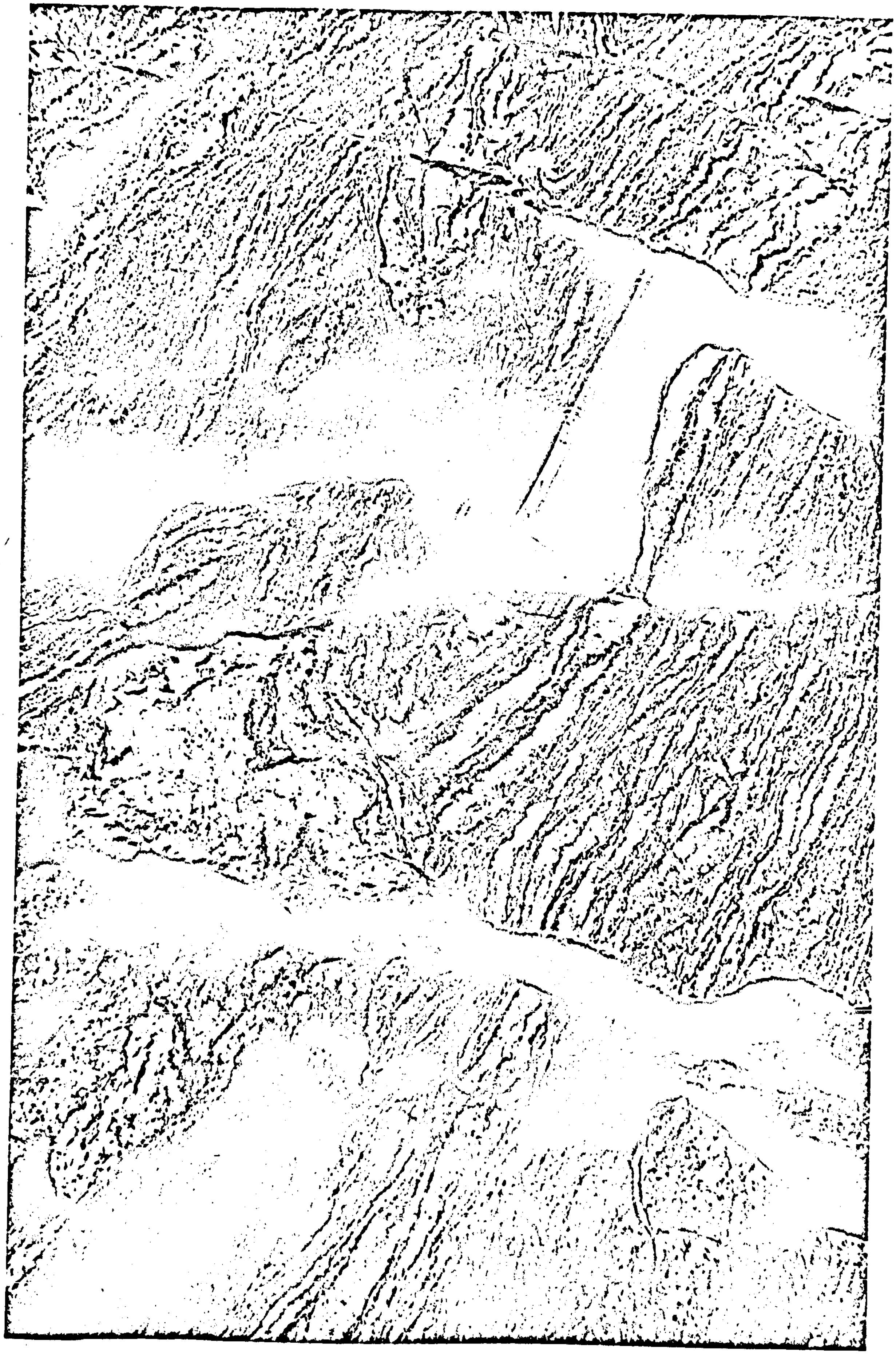


Fig. 5

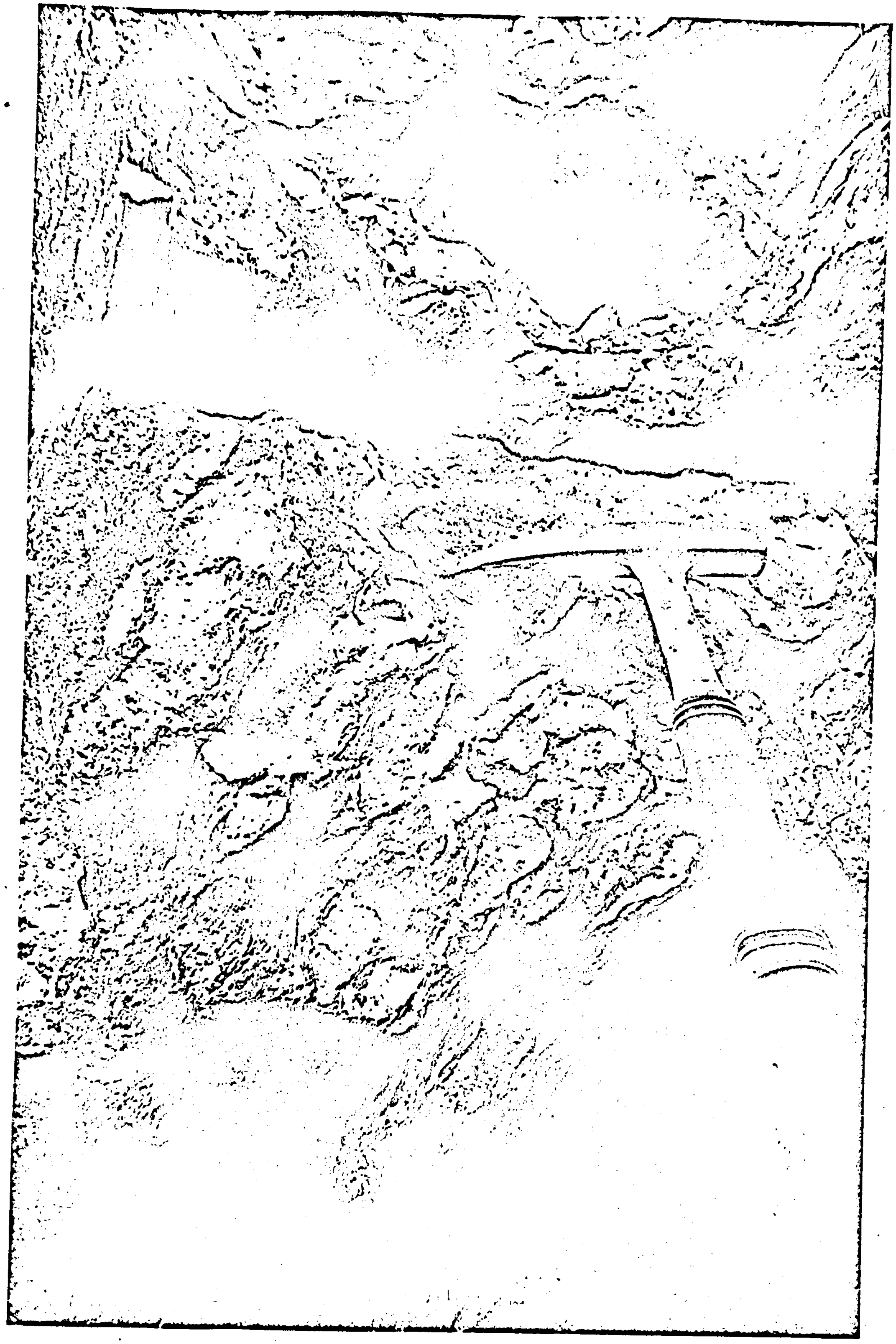


Fig. 6

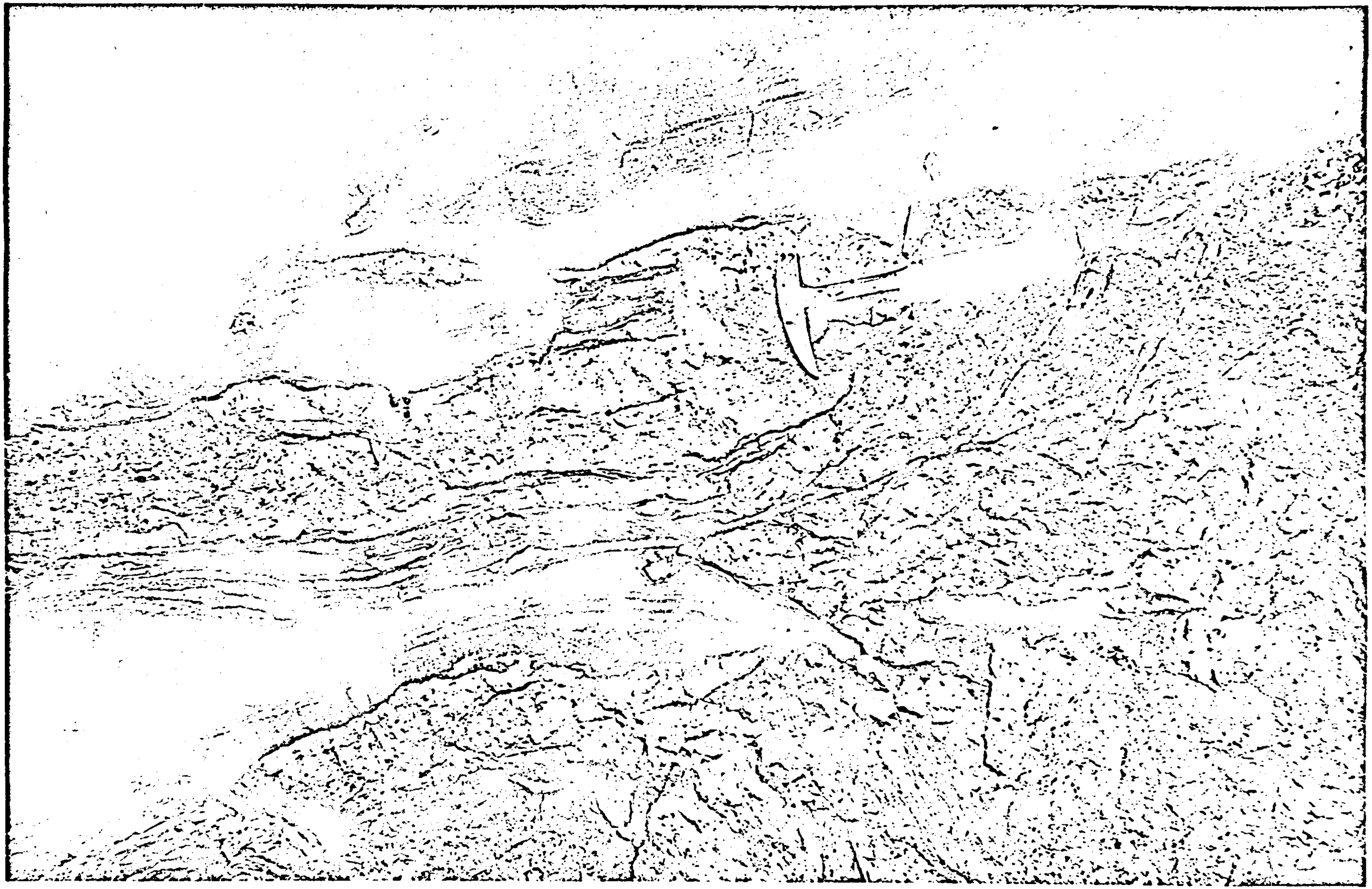


Fig. 8

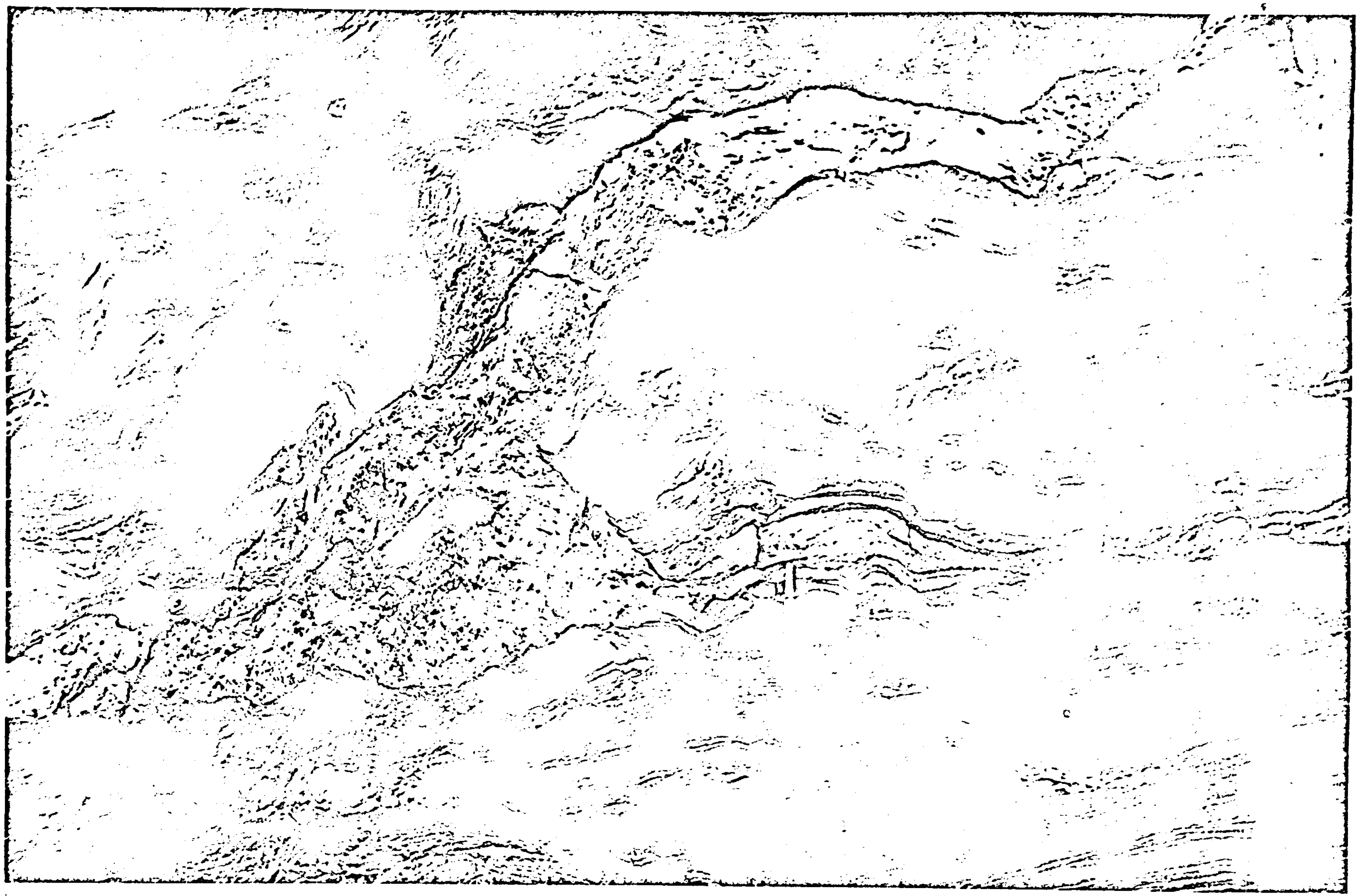


Fig. 9

Fig. 10